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ASSESSING THE ROLES OF WARD BASED APPROACH ON THE FEASIBILITY OF WASTE-TO-ENERGY IN DHAKA CITY

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ABSTRACT

In Dhaka City Corporations, Bangladesh, four systematic approaches to solid waste management (SWM) at the community level have been developed as Ward Based Approach (WBA) and applied alongside capacity building efforts through decentralization, stakeholder engagement and grassroots level planning. This qualitative study critically examines the WBA to present its linkages to the feasibility of waste-to-energy, as well as its status and sustainability issues. The study is based on in-depth online interviews, online surveys of respondents who are key professionals in the sector (e.g., model developers, senior city officials, and national consultants), and the author's actual field experience. The study shows that different components of WBA can contribute in diverse ways to various aspects of WtE feasibility. If WBA can be implemented optimally, there will be synergies to contribute the SDGs. Issues for the sustainability of WBA are identified and recommendations are made.

INTRODUCTION

Waste-to-energy (WtE) as intermediate treatment options (Table 1) under the concept of *Eco-town* has been proposed in the New Clean Dhaka Master Plans for Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC), prepared by DNCC & JICA (2019); DSCC & JICA (2019).

Table 1 Proposed waste treatment (in Eco-town) and disposal options in Master Plans

Treatment option	Incineration	Composting	Biogas	Material recovery	Recycling / Conversion	Landfill
Waste types	High heating value (e.g., high combustible)	Vegetable, (e.g., green market)	High moisture, (e.g., restaurant)	Recyclable materials (e.g., dry recyclable)	Construction & demolishing waste	Others & untreated waste

Source: Adapted from New Clean Dhaka Master Plans, DNCC & JICA (2019), DSCC & JICA (2019)

The 8th Five-Year Plan of Bangladesh (2020) envisages 48 MW renewable energy to be tapped from WtE by 2023. Bangladesh Power Development Board (BPDB), along with municipal corporations, has embarked on the rollout of WtE projects. However, no WtE project has yet been fully realized. Meanwhile, agreements were signed with two municipal corporations and two companies, as shown in Table 2.

Table 2 Information on decided WtE projects in Dhaka and Narayangonj cities

City authority	Agreement date	Land provided (acre)	Waste (t/d)	Electricity (MW/d)	Purchase rate per unit $(kW \cdot h)$		Purchase period (years)	Company	Reference
					US cents	BD Tk			
DNCC	Dec 1, 2021	30	3000	42.5	21.78	18.295	25	CMEC	Daily Star (2021)
NCC	Sept1, 2022	10	600	6.0	20.91	20.00	25	U&D	New Age (2022)

Note. DNCC: Dhaka North City Corporation; NCC: Narayangonj City Corporation, t/d: ton per day; MW/d : Megawatt per day, $kW \cdot h$: kilowatt-hour.

However, a detailed feasibility study is precursor for WtE sustainability which stresses a sound solid waste management (SWM) system in place. A combination different approaches in the name of Ward Based Approach (WBA) were piloted to improve quality and efficiency of SWM in Dhaka city which provoke to investigate how WBA can influence WtE feasibility. WBA works in generation, segregation, and collection phases of SWM.

This paper has solidified understanding by exploring *What is WBA? How does WBA play role, link and contribute to WtE feasibility? How does WBA work? What are the sustainability issues WBA? What conclusion can be drawn to support WBA in terms of WtE feasibility?* Attempts have been made to justify an assumption that *WBA can positively influence the feasibility of WtE if properly implemented.* The objective of this study is *to comprehend the roles of WBA on the feasibility WtE*.

METHODOLOGY

Study Area

The study area is Dhaka, the capital city of Bangladesh. There are two city corporations (*viz.* DNCC & DSCC) and combinedly termed as 'DCCs' hereinafter. Dhaka is a very densely populated megacities of the world. Field level SWM functions are managed by ward with the help of municipal cleaning workers, primary collection service providers (PCSP), vehicle drivers, supervising staffs e.g., conservancy inspectors (CI), conservancy officers (CO) etc. The basic SWM profiles of DCCs are shown in Table 3.

Table 3 SWM *profile* in 2019-2020, if not specified differently, updated from Mondal & Kitawaki (2022)

Solid Waste Management Profile (summary data)	DNCC	DSCC
Total jurisdiction area, km^2	196.23	109.00
Population in million	6.10	6.30
Average population density, people/km^2	31,488	57,798
SWM Budget (Million BDT)	3,467	5,888[a]
Number of zones	10	10
Total wards (old/new[b])	54(36/18)	75(57/18)
Population (x1000) in a ward (Min, Max)	16.72, 256.72	91.82, 144.24
Area of a ward in km^2 (Min, Max)	0.629, 12.224	0.135, 9.352
Estimated waste generation, t/d	3,433	3,256
Household waste, t/d	2,094	1,947
Business waste (office, market, hotel, restaurant etc.), t/d	755	1,081
Street, construction waste, t/d	584	228
Household waste generation rate, gm/person/day (income level)[c]	496(high), 483(medium), 193(low)	
Number of landfill site (name of landfill site)	1 (Amin bazar)	1 (Matuail)
Average collection rate	80%	78%
Number of SWM offices (WBA-1)	23	28
Cleaners workshop and safety instruction in 2019-2021 (WBA-2)	59	27
Separation of waste at sources in Jan 2021-May 2022 (WBA-3)	2	2
Number of waste collection vehicle (WBA-4)	163	307
Number of compactor truck (WBA-4A)	46	58
Heavy equipment	16	41
Secondary collection modes	CT, OT, CC	CT, OT, CC
Average landfill disposal, t/d	2,750	2,540
Landfill operation cost, BDT/t	244	426
Number of cleaners (average workers/day)[d]	3,914 (self, 2,479; outsourced, 1,435)	5,168

Note. 1 US$ = 84.5BDT, CT: Compactor Truck, OT: Open Truck, CC: Container Carrier,
[a]information is fiscal year 2017-2018,
[b]coverage areas added in 2011, where regular waste collection and management are yet to start fully, [c]waste generation rate for both city corporations are assumed to be save based on sample average of characterization survey, [d]all paid by DCCs.

Source: Adapted from *Waste Reports 2019-2020* by DNCC & JICA (2021); DSCC & JICA, (2021), *New Clean Dhaka Master Plan 2018-2032* by DNCC & JICA (2019), *New Clean Dhaka Master Plan 2018-2032* by DSCC & JICA (2019), Mondal & Kitawaki (2022)

Wards are the smallest administrative unit of local government typically governed by ward councilors who are elected by public representatives. There are 129 wards in DCCs. The position of ward and coverage of WBA is shown in Figure 1. The numbers in () are the organizational number taken from Bangladesh National Portal (2022) and Newspaper (2021).

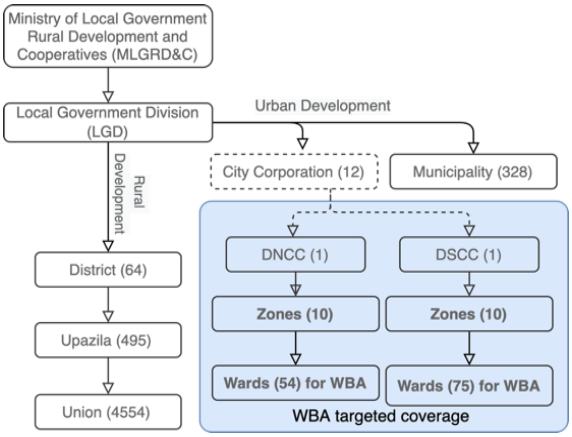


Figure 1 Position of ward and coverage of WBA

Conceptual framework of the study

As shown in Figure 2, respondents have been chosen from the careful considerations of the relevant and experienced officials of this sector. Table 4 shows the profile of participated seven (7) respondents from targeted fifteen (15).

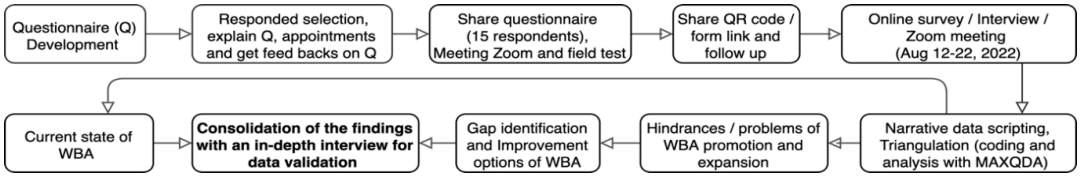


Figure 2 Conceptual framework of the study

Table 4 Profile of the respondents

Respondents	Current credentials	Experience (year)	Academic Qualifications	Number
WBA model developer	JICA Consultant	40	M.Sc.	1
Retired DCC's Official	National / UN Consultants	30-40	MPhil, PhD	2
DCC's WBA staff	Municipal employees	20-35	MBA, B.Sc. Engr., BA,	3
National SWM staff	Private company	5	B.Sc. Engr.,	1

Questionnaire (Table 5) has been designed based on the WBA explorations' areas such as WBA components' link and contribution to WtE; current state; ways to improve WBA sustainability, issues and hindrances for WBA promotion, knowledge, skills, and motivations for WBA promotion.

Twenty (20) independent questions have been put forwarded through to scan the respondents' observations and experiences on WBA phenomena. Three (3) response taking approaches undertaken: (1) open ended by typing or recording voices on statement of the facts, (2) 4 x 5 matrix-Likert scales, e.g., *4 WBA (1,2,3,4) x 5 functional status (non, slightly, functional, as expected, excellently),* and (3) multiple choices, e.g., *yes*, *no*, *may be*. All the questions and explanatory notes, etc. were both in native language and English. Microsoft Forms were developed and accessible from mobile and PC. All the respondents did not use the forms, interview meetings and communications were held through email, zoom, WhatsApp and messenger and with permission voice recordings were done.

Table 5 Online survey questionnaire

No.	Question	Answering Pattern
1	How can a ward office (WBA-1) help the feasibility of WTE?	
2	How can the work of waste workers (WBA-2) help the feasibility of WTE?	Open ended, narrative
3	How can community-lead participatory SWM (WBA-3) help the feasibility of WTE?	

No.	Question	Answering Pattern
4	How can improving /modernizing collection (WBA-4) help the feasibility of WTE?	
5	What is your assessment of current WBA functional status?	4 x 5 Matrix-Likert scale
6-9	Please list up few points to boost sustainability and function of WBA 1,2,3,4	Open ended narrative
10	How likely is the role of WBA in WTE feasibility?	4 x 5 Matrix-Likert scale
11	In how many wards does your CC have ***waste separation at the source***?	
12	In how many wards *segregated **primary** collection* started in your CC?	Number
13	In how many wards *segregated **secondary** collection* started in your CC?	
14	Do you think waste separation is important for waste to energy?	Multiple-choice
15	Please list up issues/hindrances on WBA 1,2,3,4, implementation, and expansion	
16 - 19	Please recommend some knowledge & skills required to implement WBA-1,2,3,4	Open ended, narrative
20	Please recommend some motivational strategies for WBA-1,2,3,4 implementation	

Note. Slightly paraphrased (shorted) from original Bangla version keeping the senses same

Data Analysis Methods

Since data have come from different respondents and in different forms like (e.g., short, or long texts, voices records, zoom records), first generalization is made by simple scripting. And then the pieces of information have been coded and classified further based on the context and matching between raw data and questionnaires. Triangulation is used to gain a comprehensive and deeper conceptualization of WBA phenomena and its link to WtE using MAXQDA for text mining.

WARD BASED APPROACH CONCEPT

Concept of WBA was emerged from a development study through the formulation of first Clean Dhaka Master Plan (JICA, DCC, 2005), and afterwards it has been matured by the Technical Assistance (*viz.* Cooperation) projects supported by Japan Government from 2007 to 2013 and from 2017 to 2022. Four (4) decentralized-SWM-approaches as WBA were modeled, piloted, and scaled up in DCCs. WBA is a systematic framework of thinking and organizing field works of MSW management in collection phase (i.e., grass-roots level). WBA works through the strengthening horizonal (i.e., parallel) and vertical (i.e., hierarchical) management tiers where most of the activity initiatives are expected to be bottom up and budgetary and human resources support are mostly top-down. Mechanisms of voluntarism, citizens' engagement, flexibility, and resources mobilizations scopes are there.

According to the published papers by different authors in different languages on WBA, it is found that WBA has been applied in Africa and comparative studies are made (Kodani et al., 2020; Oseko, 2020; Oseko & Ishii, 2012, 2016; Sato & Okamoto, 2007). And latest status of WBA in Dhaka is mentioned in *New Clean Dhaka Master Plan 2018-2032*, DNCC & JICA (2019), DSCC & JICA (2019).

The WBA themes and components are outlined in Table 6 and the scopes in two-sequenced (e.g., primary, and secondary) waste collection is shown in Figure 3.

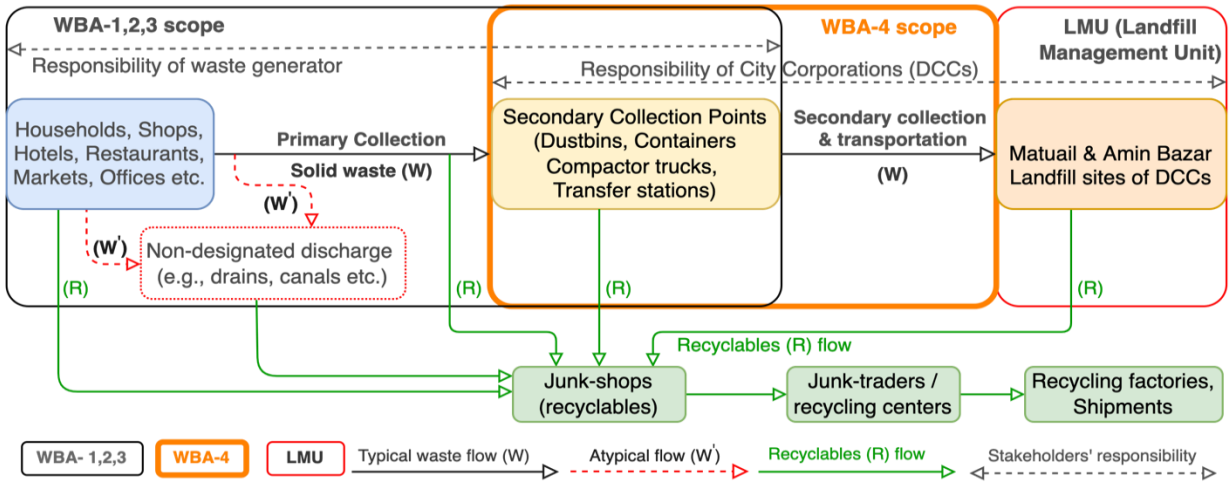
WBA-1 deals with formation of decentralized SWM organization through the construction and functioning of ward SWM offices. WBA-2 is for improving work environment of the waste workers enhancing occupational health and safety, productivity and working pride. WBA-3 works for participatory community based SWM which is community centric approach about local SWM planning in coordination with three (3) stakeholders (*viz.* DCCs, PCSP and community). WBA-4 facilitates modernizing waste collection system through the introduction of new compactor truck based fixed time and fixed place (FTFP) system and improve existing system. FTFP systems are outlined in different literature, such as DSCC & JICA (2021), Mondal (2011). It is a system without requiring secondary collection points (e.g., dustbins, containers etc.) and vehicles take the waste from nearby point of generation to the landfill.

Table 6 Concept of Ward Based Approach (WBA)

Approaches	WBA-1	WBA-2	WBA-3	WBA-4
Theme	Institutionalize the SWM by ward SWM Offices through decentralizing activities from headquarter to field level	Waste workers' work environment and pride improvement through safety and sanitation	Community based participatory SWM	Collection system modernization and improvement
Hard component	Renovation, construction of ward SWM offices equipped with facilities of toilet, storage, meeting, furniture, notice board, bulletin board, and utilities (water supply, electricity)	Provision, arrangement, supply, usage of safety gears (e.g., masks, hand gloves, apron, gum boots, etc.)	Special cleaning campaign, leaflets, posters, banners etc.	Demolish dustbins, remove constrainers and FTFP* promotion
Soft component	Ward SWM data management, reporting document preparation, bookkeeping, community meetings, trainings / workshops arrangement, communication and information point	Cleaners' workshops for occupational health and safety, empower safety and sanitation committee	CUWG training, CAP, miking, rally, cultural program etc.	Drivers' training, community, PCSP and DCC meeting for collection planning

Note. FTFP: Fixed Time Fixed Place collection system, DSCC & JICA (2021), Mondal(2011); CAP: Community Action Plan, Prashar et al., (2013);

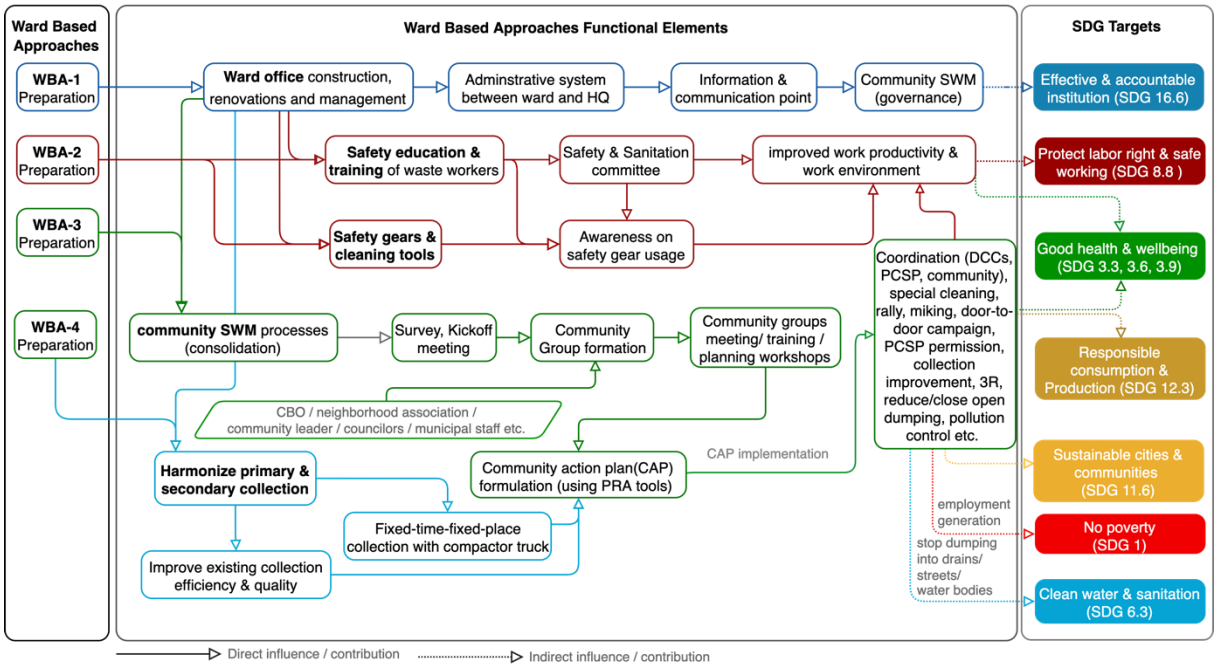
Source: Adapted from interview survey (2022)



Source: Adapted from Mondal & Kitawaki (2022), DNCC & JICA (2019), DSCC & JICA (2019)

Figure 3 Two sequenced waste collection and scope of WBA in Dhaka city

The typical functional elements of WBA and how their outputs contribute to the global goals are outlined in Figure 4. There are synergistic effects of WBA in improving local organization, sanitation, job creation and governance.



Source: authors' survey (2022).

Figure 2 Mind map of the synergic effects of WBA activities towards SDGs

SCOPING REVIEW OF WTE INCINERATION FEASIBILITY STUDIES

The feasibility of WtE has been considered from different angles and perspectives in the existing literature. World Bank (1999) suggested seven (7) aspects in technical feasibility: (1) *plant location*; (2) *incineration technology*; (3) *energy recovery*; (4) *air pollution control*; (5) *incineration residues*; (6) *operation* and *maintenance*; (7) *environmental impact* and *occupation health*. And these are further sub-divided into thirty-two (32) key assessment criteria including waste should be $\geq 6\,MJ/kg$ in all seasons.

Gohlke & Martin (2007) pointed out that *Premium* for renewable energy in European cities acted as driving force behind the implementation of high-energy system in WtE plants and regulations that restricted landfilling municipal waste. US EPA (2012) delineated six (6) factors contributed to the failure or non-feasibility incineration-based WtE plants: (1) *inability* or *unwillingness to* pay *the full treatment fee*, *insufficient revenue* to *cover loan and O&M costs*; (2) *lack of convertible currency to purchase spare parts;* (3) *O&M failures (e.g., lack of skilled workers)*;(4) *problems with the waste quality and quantity (e.g., calorific value)*; (5) *poor plant management,* and (6) *inadequate institutional arrangements.*

Song et al., (2017) carried out PESTEL analysis for systematic analysis of macro-environment in China citing several others from different regions of the world. PESTEL framework guides a comprehensive analysis considering six (6) domains such as *Political* (e.g., legislation, policies), *Economic* (e.g., major sources of income, investment intensity, investment mode, subsidies from government, energy price, scale of investment etc.), *Social* (e.g., public concern, culture, solutions to opposition), *Technical* (e.g., waste composition, heating value, grate or fluidized type, technique with or without axillary fuel like coal), *Environmental* (e.g., pollution and environmental risk control, environmental protection expenses,) and *Legal aspects* (e.g., industrial, economic, technological, and environmental protection legislation and policies). Mutz et al., (2017), published from GIZ GmbH coined a decision matrix for developing and emerging countries with twelve (12) essential parameters with forty-eight (48) criteria (i.e., each parameter has 4 distinguishing criteria) to consider local context for justifying pre-conditions for feasibility study. However, more advance evaluation is suggested after initial feasibility assessment. The 12 parameters for feasibility checking are (1) Overall level of waste management; (2) Composition of waste; (3) Calorific value of MSW for thermal processes, organic content; (4) Suitable quantities of waste for WtE; (5) Efficient operation of waste facilities; (6) Additional transportation time and distance for MSW to WtE plant; (7) Marketing and/or final disposal of process residues; (8) Legal framework & environmental requirements for WtE; (9) Financing the management of MSW; (10) Access to foreign currency; (11) Access to energy end-users; (12) Incentives for low carbon energy generation.

IGES, IETC and UNEP (2020) mentioned twenty-four (24) key evaluation criteria at the planning stage of appropriate technology which are composed on six (6) sustainability aspects: (1) *Social*, (2) *Public awareness and residents' cooperation*, (3) *Institutional*, (4) *Governance capability*, (5) *Finance* and (6) *Technological.* This is the latest guiding document for planning and feasibility aspects of WtE incineration, that tells mandatory criteria under *social aspect* is specific population and *appropriate system of waste collection management.*

Social and organizational aspects have been shown to be common in WtE feasibility studies under governance. This includes not only citizen awareness and participation, but also the prevention of complaints. Another crucial point is the calorific value of the waste should have a certain level that can be achieved through proper segregation and controlled collection, and community participation is necessary. This paper explores the role that WBA can play in these areas to improve feasibility of WtE.

RESULTS AND DISCUSSIONS

Decentralization of SWM by Ward Office (WBA-1) and WtE Feasibility

Ward SWM office helps to engage citizen to local SWM and try to solve issues locally. CI is a custodian of the office. It can be regarded as grass-roots level common platform for participatory SWM. The waste collection and cleaning works are done by thousands of touch-labors every day. A sizable fraction of them is female. A ward office helps for taking their attendance, meetings, cleaning equipment storage, toilet facilities, shelter at extreme weather etc. It also helps for information and data source for ward SWM, and it can control the quality of waste heading to the incineration plant through regular monitoring by CI, and cleaners' supervisor (called *sardar*).

Some offices under WBA-1 keep the information of waste (e.g., trips/day, tons/day), vehicles (e.g., open truck, compactor truck), cleaners (e.g., attendance, contact details), shops/market representees contacts, community/housing/neighborhood association leaders contacts, ward councilors or secretaries contacts, PCSP information etc. Strategic discussions through information sharing, consensus making with citizen, political leaders, recycling entities are possible from ward offices to ensure quality waste collection, and recycling activities. The recycling pattern within the ward (i.e., community level) is mostly dirty without health-safety consideration. Ward office can take the roles for gradual shifting to quality recycling or environmentally sustainable recycling. Megacities (e.g., Tokyo) have ward offices to control and manage waste management including incineration plants with all facilities and arrangement for citizen e.g., environmental education, meeting place, social safety, and services etc. (personal communication, August 11, 2022). The category of waste for incineration (combustible) to be maximized and others to be avoided (e.g., sand, stone, drain sludge etc.) which needs constant monitoring and regular consultation, education by municipal staff towards citizen, community association, vehicle drivers, PCSPs etc. Therefore, CI should play key role as focal point for information, education, and communication from the common platform (ward SWM office) under WBA-1. The number of SWM offices are 23 (out of 54) in DNCC and 28 (out of 75) in DSCC which are quite insufficient to provide improved SWM services, control waste quality, ensure community engagement etc. They are being used by cleaners, community meetings and some cases ward councilors' monitoring and citizen's mobilizing. However, children SWM education, more community engagement will be required as responded mentioned. Ward office functions to be strengthen (e.g., by staff and resources) and broaden more (e.g., by locally solving issues, locally managing vehicle and cleaner, campaign and education management, residence registration etc.) gradually seeing other developed economies pattern of development e.g., 23 wards of Tokyo Metropolitan Government (*TMG and the 23 Special Wards*, 2022).

Waste Workers Work Environment, Safety, Pride (WBA-2) and WtE Feasibility

WBA-2 addresses the work environment, safety, productivity, and pride of the four (4) types of waste workers: (a) street, sidewalk, foot-over bridge, and market cleaners, (b) drain cleaners, (c) primary waste collectors, and (d) vehicle crews. Approximately 9,000 DCCs' cleaners and 6,500 PCSPs' collectors work daily. They are the touch-labor and directly exposed to waste and dependable to increase the waste collection amount, control the waste flow and enhance informal recycling amount. Respondents feel the need of massive effort to ensure their waste quality awareness which should be going to the plant, and which are not as for example, vehicles with fallen trees, leaves, garden trimmings have higher energy content they should be going to the incineration plant on the other hand construction waste or drain cleaning waste should be going to the landfill site without mixing to combustibles. Similarly, restaurant waste with food content and moisture content may go to anaerobic digestion plant while the fresh vegetable waste from green kitchen market can go to straight way to composting plant without any mixing. Such information and education are necessary under WBA-2 to the waste workers through proper signs and symbols of waste as respondents mentioned. However, according to the survey, the number of cleaners' workshop held in DNCC and DSCC are 59 and 27 respectively between

2019 and 2021 and it needs continuation as routine work. Four (4) main insufficiencies are to overcome: *the number of cleaners' workshops compared to the wards, the availability and use of safety equipment, knowledge on signs and symbols of waste, the formation and activation of safety and sanitation committees* (i.e., consisting of representatives of the cleaners and municipal staff in each district). Although cleaners are part of the government staff and do a noble job, their work is still neglected by many as lower caste work and not much is done for their work pride, except for the few workshops and the recent allocation of new housing and health facilities. Respondents suggested moving away from the traditional management of cleaners at the organizational level. They can be provided with more welfare (i.e., insurance, housing, health care, etc.) to achieve higher productivity under privatization with almost no cost increment. Entrepreneurship, microfinance, cooperative, knowledge, motivation, capacity building models, etc. can be associated with them to enable them to make a better living. In such case DCCs may channel corporate social responsibility (CSR) funds from business communities.

Community based Participatory SWM (WBA-3) and WtE Feasibility

WBA-3 addresses SWM planning and implementation at the community level through problem analysis and action planning workshops to formulate CAPs (Community Action Plan). This platform is considered as the main channel for dissemination of community level information in a ward. WtE requires strong community participation in new collection systems such as plastic or paper bag collection, source separation of waste, neutralization movement against incinerators, etc. Improving waste treatment might require an increase in the service fee or a change in the tax rate, which in turn requires consultations, pilot projects, etc., which the WBA-3 framework can help with. On the other hand, massive environmental education on waste separation is needed, and such activities can be included in the CAPs through PRA tools as described by Prashar et al. (2013) and Chambers R. (Chambers, 1994a, 1994b).

Modernizing and Improving Collection System (WBA-4) and WtE Feasibility

Under WBA-4, FTFP collection system has been introduced in many places in Dhaka, replacing removable containers. An improved and efficient collection system is a prerequisite for continuous and quality waste feed to WtE plant. According to the survey results, this could only be possible with compactor trucks that can leach moisture or protect waste from rainwater and easily dump into the WtE bunker. There are only 46 and 58 compactor trucks of different capacities which are carrying around 725 t/d in DNCC and 250 t/d in DSCC of mixed waste, respectively. Existing allocation pattern of vehicles will hinder to comply with schedule, quality of waste etc. to WtE plant due to cross-border collections. It has been urged that vehicles should be allocated against each ward without being moved to another ward which improves the capacity of a ward in terms of decentralization as a pillar of governance.

WBA Sustainability Factors

WBA sustainability relies on five (5) thematic factors, which are as follows: (1) *Knowledge & skills for WBA, (2) Motivation, (3) Articulated guiding aids, (4) Key stakeholders, (5) Governance strengths.* The sustainability factors that need to be promoted more strongly in order to activate and expand them are summarized in Table 7.

Knowledge denotes the concepts or ideas or information for the WBA based on staff on the job training (e.g., learning) and on the job doing (e.g., experience). And *skills* are expertise developed through demonstration and having experiences. On the other hand, *motivation* triggers *knowledge and skills for WBA*. *Motivation* catalyzes the interest to act for WBA by the self-initiatives. It has been found that staff with higher motivations (i.e., more enthusiastic) are more knowledgeable and skillful for promoting SWM through WBA based on the records of self-initiatives. The example of self-self-initiatives of DCCs' staff are finding place for ward SWM office (WBA-1), arrangement of safety gears, check usage and cleaners group meeting / safety training (WBA-2) with routine cleaning work supervision, organize community meetings in different communities (i.e., housing society, shop owners' association, market committee etc.) for different issues such closing open dumping points or starting separation of waste at households etc. (WBA-3); and harmonize primary & secondary collection to improve collection system towards more efficient and effective (WBA-4).

Articulated guiding aids are various documents to guide the promotion and implementation of WBA. As for example, a documentary audio-visual (DVD) that shows the concept of different WBA components with how to organize and function. WBA booklets/manuals show different WBA process, principles, and progress in the form of a booklet or pocketbook. Community SWM guidelines shows functional steps with process and principles of participatory SWM, it shows stakeholders and their roles, guides to formulate community CAP etc. Community unit working groups (CUWG), and PCSP training modules are prepared targeting trainer (e.g., CIs, COs) to provide training CUWG and PCSP.

Key stakeholders for different WBA components will vary with locations or wards. However, the three (3) stakeholders are involved. Such as city corporation (i.e., municipal staff, ward councilor), PCSP (i.e., primary collector and organization), CUWG (i.e., community association, shop owners' association, market committee etc.). All can play together important roles on waste collection service efficiency improvement and waste quality improvement for WtE plant through information, education, and communication towards society. *Governance Strengths* are not extremely high according to the survey respondent. Though there are office orders, formal training, and certification of the staff members in home and abroad; however, more effort is needed in terms of assigning responsibilities to the staff members, decision making on WBA and resource allocations to make it more sustainable.

Table 7 Sustainability factors of WBA

WBA	WBA-1	WBA-2	WBA-3	WBA-4
Knowledge & skills for WBA	PPR to use government fund. Design, drawing, BOQ, estimate, tendering for construction; book-keeping SWM data, ward profile etc.	Training & workshops of waste workers, health and safety, leadership, facilitation & communication; street, drain and market cleaning tools, usage and activities, all roads and drains network of a ward, SWM Rules	3R and environmental education, Communication and facilitation of community meetings, trainings and various awareness raising programs, Effective language to facilitate community activities, PRA tools and principles, Participatory monitoring, CAP formulation with governance component, 3R, SWM Rules	Communication and facilitation, PRA tools and principles, CAP formulation with physical component, waste collection design, harmonize (*viz.* time, place, process) primary and secondary collection, all roads of a ward, collection and transportation plan, collection methods and design, loading capacity, fuel consumption ratio of different vehicles, SWM Rules etc.
Motivation WBA	Growing dignity and pride waste staff and waste workers. Potential for self-self-initiative	Growing dignity and pride waste staff and waste workers, grouping and leadership developments, Potential for self-initiative	Growing dignity and pride waste staff and waste workers. Potential for self-initiative	Growing dignity and pride waste staff and waste workers. Potential for self-initiative
Articulated guiding principles	DVD, WBA Manual, data formats and templates, ward profile, reporting system etc.	DVD, WBA Manual, Cleaners working manual	DVD, WBA Manual, training modules (e.g., CUWG, PCSP), CAP, Community SWM guidelines	DVD,WBA Manual, PCSP Training module, CUWG training module, CAP
Key stakeholders	CI, Asst./Executive Engineer	CI, Safety & Sanitation Committee	CI, CUWG, Ward Councilor, PCSP	CI, Ward Councilor, PCSP
Governance Strengths	Office orders for WBA considering routing work and reporting from ward SWM office (Office Order, 2010; Office order, 2012), Training of counterpart in home and abroad, WBA Core group formation, budget for community SWM.			

Note. PPR: Public Procurement Rules 2008; PRA: Participatory Rural Appraisal, Chambers (Chambers, 1994a, 1994b); CUWG: Community Unit Working Group; CAP: Community Action Plan; CI: Conservancy Inspector; PCSP: Primary Collection Service Provider;

The recommended sustainability improvement options are (1) encourage CI, CO continuously by incentives, paid leaves, promotions, recruiting quality graduates, (2) citizens, school students and mass medias exchange opinions on SWM now and future, and must visit collection area, landfill site by the arrangement of separate organization (e.g., private entity) under the articulated guidance and some facilitations of DCCs; (3) realize Clean Dhaka Master Plan with waste management organizational structure and efficient staffing to make the difference (4) community to be given supervisory responsibilities through WBA as demonstrated in DNCC (e.g., Uttara R/A, Niketan society R/A) and DSCC (e.g., Lane 28, Dhanmondi R/A); (5) it is necessary to implement the WBA performance

measurement with approved measurement process; (6) creation awarding tradition among the officials for WBA (e.g., zone wise and city based); (7) annual training program for WBA and reporting system; (8) establish knowledge management (KM) culture and infrastructure retaining organizational memory.

Factors Hindering WBA Functions and Feasibility of WtE

The seven (7) major factors are hindering effective implementation of WBA, thus will hamper WtE feasibility unless measures are undertaken: *(a) lack of human resources, (b) poor knowledge management, (c) weak budget utilization potentials, (d) weak stakeholders' collaboration, (e) irrational organizational focus, (f) lack of good governance, (g) improper collection.*

There is dire need of sufficient number of knowledgeable, skillful, and motivated *human resources.* And the number of staff members are far less than officially approved positions. There is not enough quality graduate, as basic salary is low and educational qualifications of many are low, no clear carrier growth in conservancy wing, if compared with other sectors or government offices like police, defenses etc. while working hardship is quite high for CI, CO etc. for grass-roots activities of WBA. Motivation or incentives are not much. There is need of training newly recruited high official as well as field staff.

Knowledge management (KM) system as reviewed by Alavi, M., Leidner, D.E. (2001) are mostly absent and not fully established in DCCs' SWM. They are very poorly practiced in limited scale by the organization due to lack of KM culture and infrastructures. Respondent opined it is not only in SWM sector but its common most of the sector and many of government offices in Bangladesh. The most crucial problem is temporary departmental heads of Waste Management Department (WMD) mobilized from other department of separate organization who typically do not have proper SWM system design or service delivery experiences in a megacities setup. Though it does not take much time to conceptualize the SWM system and service delivery mechanisms and routine duties by *explicit knowledge*, but they need to be back to original place mostly before making a significant contribution to take the SWM to the next level in both *governance* (e.g., SWM service users & providers inclusivity, sound institution and proactive policies. and financial sustainability) and *physical* (e.g., collection, 3R, and treatment & disposal) components by creating *implicit knowledge*. *Governance and physical* components are delineated under the concept of integrated SWM, mentioned by Wilson et al., (2014). Respondents also cited there are "very minimum culture," and "limited administrative process" for promoting *KM* or *corporate organizational memory* for SWM.

Though there are *allocated budgets,* but due to lack of demonstrated skills and complicacies in cost adjustments a vast majority of the community SWM budget (WBA) are not utilized. The vast majority of the non-engineering wing staff (e.g., CI, CO) felt adjustment of the money is complicated and time consuming. However, on the other hand, engineering wing staff feels opposite as its common and easy. Construction, procurements etc. are routine job of engineering staff already mainstreamed, however, conservancy wing staff are still not confident and interested enough on the spending public money.

Stakeholders' engagement for research and development is almost missing. There is no officially established collaborative practices among universities, government (i.e., DCCs) and private organizations (e.g., industries, NGOs), which is mostly common in the developed economies. Mobilization of external sources in the form of financial resources (e.g., donations for cleaning or safety equipment or materials) and human resources (e.g., volunteers, civil society) is present, but its scope is limited and comes into play only on certain occasions (e.g., waste disposal at festivals, slaughter waste disposal, livestock markets, etc.). Respondents mentioned resources could be secured in other areas such as procurement of office furniture (WBA-1), training of cleaners and procurement of safety equipment (WBA-2), environmental education (WBA-3), primary collection (WBA-4) as CSR funds.

Organizational focus is much on engineering rather than management which is found to be very short-sighted approach. There is lack of combination and *longer-term plan and rolling plan* such as time-bound target-oriented plan for daily execution to achieve long term goal. Most of the works are *event based (i.e., temporary)*, routine or regular basis which may not have long term impact or significant impact quickly. There is much work on the *regular cleaning* but *little work to minimize the cleaning needs* such as how to work 'not to make' the roads or drains getting dirty. And efficient and modern collection vehicles and equipment are inevitable as operational logistics. The purchasing officials needs to pay special attention towards their quality, operation, and maintenance. However, there are records that couple of compactor trucks, mechanical street sweeper could not last long and within a noticeably short time they were damaged. There is not yet zone/ward wise plan connecting the central SWM masterplan.

There is lack of *good governance* in many aspects such accountability, transparency, rule of low, inclusivity, participation etc. However, survey identified priority needs such as to have more office orders for grass-roots official to implement WBA, gap of experience sharing scopes in both directions of horizontal (i.e., parallel or peers) and vertical (i.e., top down or bottom up) among field level and

decision-making level official. Accessibility of WBA related previous records (i.e., list of WBA activities, challenges to implement activities, learnings from those activities etc.,) to all staff members, resource and reasonability allocations are not yet clear and rational to implement all WBA components. There is lack of information discloser system to community level about WBA components.

Improper collection exists in terms of segregations. The necessity to segregate waste and follow the *SWM Rules* (2021) about segregated collection is stressed. There is mixed discharge and informal separation. The current stage of segregation is done for *monetary gain* by the marginal people of the society; but it needs conversion to *environmental gain* by the society through scaling up of segregation. WBA may function more effectively keeping city clean and contributing to WtE if factors are managed.

CONCLUSIONS

WBA can influence the feasibility of WtE. However, the WBA adaption and implementation as routine work management is needed to maximize its contribution towards WtE. Motivation of the staff members for promoting WBA is found key factors for sustainability which can be boost by work recognition, salary structure modification, incentives, promotion etc. There is total 129 wards in Dhaka city, but there is only 51 ward SWM offices. WBA-1 (ward office functioning) can be considered as information-education-communication hub and grass-roots coordination center for a ward for other components of WBA. Each ward should have one well-equipped ward SWM office to provide daily SWM service smoothly to the citizen. WBA-2 (cleaners working environment and productivity) can ensure quality of waste by minimizing objectionable of waste (metal, stones, sands, construction waste, drain sludge etc.) and maximizing combustible fractions (e.g., papers, plastics, fabrics, garden trimmings, leaves etc.). WBA 3 (community SWM) can help for improved tariff structure, environmental education for waste sorting and their categorical signs and symbols. WBA-4 (waste collection) can facilitate to improve waste collection efficiency and effectiveness using compactor truck. Only compactor to be used for waste collection which destined to be WtE incineration plants, but their number may not be enough and will require allocations. Knowledge management practices are to be mainstreamed and human resources shortage to be full filled. It may be difficult for a CI to implement WBA in his ward alone.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly*, *25*(1), 107.

Chambers, R. (1994a). Participatory rural appraisal (PRA): Analysis of experience. *World Development*, *22*(9), 1253–1268. https://doi.org/10.1016/0305-750X(94)90003-5

Chambers, R. (1994b). Participatory rural appraisal (PRA): Challenges, potentials and paradigm. *World Development*, *22*(10), 1437–1454. https://doi.org/10.1016/0305-750X(94)90030-2

Daily Star. (2022). Agreement signed to set up Bangladesh's 2nd waste-to-energy project. *The Daily Star*. https://www.thedailystar.net/environment/natural-resources/energ... 3108711

Office order to adopt WBA as regular official duties of WMD, Ref. 196 (9/3/2010), WMD, DCC (2010).

Office order for WBA reporting, Ref. 46.207.016.12.00.120.2012, DSCC, WMD (2012).

DNCC & JICA. (2019). *Future Vision of SWM ……* (p. 189) [Master Plan]. Dhaka North

DNCC & JICA. (2021). *Waste Report 2019-2020* [Waste Report]. Dhaka North City Corporation.

Solid Waste Management Rules, 2021, Pub. L. No. S, R, O No. 357-Act / 2021, DOE, GOB (2021).

DSCC & JICA. (2019). *Future Vision of SWM….* (p. 185) [Master Plan]. Dhaka South City Corporation.

DSCC & JICA. (2021). *Waste Management Report 2019-2020* (p. 61). Dhaka South City Corporation.

EPA. (2012). *Municipal Solid Waste Generation, Recycling and Disposal in the US*.

GED.(2020). *8th Five-year plan, July 2020-June 2025*. General Economic Div., Pl. Com., BD, GOB

Gohlke, O., & Martin, J. (2007). Drivers for innovation in WtE technology. *WM&R*, *25*(3), 214–219.

Ishii, A. (2022, August 11). *Interview for understanding ward office in Tokyo* [Face to face meeting].

JICA & DCC. (2005). *The study on the solid waste management in Dhaka city*. PCI,YEC.

Kodani, R., Sano, Y., & Ishii, A. (2020). Comparative case study on introducing a WBA in urban SWM -Case studies in Dhaka, Bangladesh and Khartoum, Sudan-. *Con. proc. of JSMCWM*, *31*, 139.

Liu, C., Nishiyama, T., Gamaralalage, P. J. D., Onogawa, K., Hotta, Y., & Honda, S. (2020). Waste-to-Energy Incineration. *IGES, UNEP*, 45.

Mondal, Md. S. A., & Kitawaki, H. (2022). Developing empirical model for heating value of MSW to assess waste-to-energy incineration feasibility: Study in Dhaka city. S. *Journal of MCWM*

Mondal, Md. S. A., & Kitawaki, H. (2022). Policies and Practices of PCSPs in Dhaka, JS MCWM (33)

Mutz, D., Hengevoss, D., Hugi, C., & Gross, T. (2017). *Waste-to-Energy Options in Municipal Solid Waste Management*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), GmbH. Bonn and Eschborn, Germany. https://www.giz.de/en/html/index.html

New Age. (2021). Deal to set up Bangladesh's first-ever waste-to-energy project signed.

Oseko, M. (2020). Localization of Collection and Transportation Through Integration: Improvement Model for Urban SWM of Developing Countries. In S. K. Ghosh (Ed.), Sustainable *Waste Management: Policies and Case Studies* (pp. 717–725).

Oseko, M., & Ishii, A. (2012). Urban SWM in Developing Countries—A Model for Collection and Transport Improvement in the Smallest Unit of Administrative Division. *The 23rd Research Presentation Society for Waste Resource Recycling*, *23*, 159.

Oseko, M., & Ishii, A. (2016). Waste management in urban areas in developing countries—Minimum administrative unit collection…. (Translated). *Journal of Japan Society of MCWM*, *27*, 71–83.

People's Republic of Bangladesh. (2022, November 28). https://bangladesh.gov.bd/index.php

Prashar, S., Shaw, R., & Takeuchi, Y. (2013). Community action planning in East Delhi: A participatory approach to build…. *Mitigation and Adaptation Strategies for Global Change*, *18*(4), 429–448.

Sato, A., & Okamoto, J. (2007). *Model Development of People's Participatory SWM in Dhaka City – Through the Experience of Pilot Project for Solid Waste Management at Ward Level*.

Mondal, Md.S. A. (2011). *Determination of efficiency indicators …* [M.Sc. Thesis, BUET].

Song, J., Sun, Y., & Jin, L. (2017). PESTEL analysis of the development of the waste-to-energy incineration industry in China. *Renewable and Sustainable Energy Reviews*, *80*, 276–289.

Sr. Correspondent. (2021, July 26). Bangladesh adds three new Upazilas. *BDnews24*.

TMG and the 23 Special Wards.(n.d.). TMG. Retrieved October 14, 2022, from https://www.metro.tokyo.lg.jp/english/about/structure/structure02.html

Wilson, D., Rodic, L., Cowing, M., Velis, K., Whiteman, A., Scheinberg, A., Vilches, R., Masterson, D., Stretz, J., & Oelz, B. (2014). *'Wasteaware' Benchmark Indicators for ISWM in Cities*. 28.

World Bank. (1999). *Municipal Solid Waste Incineration* (p. 112) [Technical Guidance Report].